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IMPROVEMENT OF POWER QUALITY (PQ) BY UPQC (UNIFIED POWER QUALITY CONDITIONER) IN POWER SYSTEM USING ADAPTIVE NEURO FUZZY (ANFIS) TECHNIQUE

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ABSTRACT

The main motive of power utilities is to provide uninterrupted sinusoidal voltage of constant amplitude to their customers. This depends upon the loads and their sensitivity to supply voltage fluctuations. In the last few years the quality of power is the very serious issue in the power system. These issues related to power system quality are more attentive in power electronic devices. So these all power electronic devices are largely affected by the PQ disturbances. Various devices are used for compensation of problems related to power quality for continuously change in voltage. There is one device named Unified Power Quality Conditioner (UPQC) is used for the loss due to PQ fluctuations. It is a combination of series compensator DVR (Dynamic Voltage Restorer) & Shunt Active Power Filter (APF) or Distribution STATCOM connected with the help of a DC link capacitor. This device used successfully for almost all the disturbances such as voltage and current harmonics, unbalanced voltage and current, voltage flicker, Voltage sag and voltage swell [12] etc. There are many optimization techniques to improve the PQ in the transmission and distribution system.

Key words: Power Quality (PQ) improvement, UPQC, DVR, Shunt Active Filter i.e. DSTATCOM [6, 7] etc, Voltage Fluctuations, Voltage sag and swell, Voltage and Current Fluctuations, ANFIS (Adaptive Neuro-Fuzzy Inference System).

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1. INTRODUCTION

PQ means how well the quality of electric power to consumer. The power system has four major areas.

(i) Electric Power Generation
(ii) Power Transmission
(iii) Power Distribution and
(iv) End Users or consumers.

According to Institute of Electrical & Electronics Engineers (IEEE) Standard 1159-1995 (IEEE Std 519, 1995) power quality (PQ) is defined as the concept of powering and grounding the electronic equipments in a manner that is suitable to the operation of that equipment and compatible with the premise wiring system and other connected equipment. International Electro-technical Commission (IEC) defined PQ as a set of parameters defining the properties of PQ as delivered to the user in normal operating conditions in terms of continuity of supply and characteristics of voltage (frequency, magnitude, waveform and symmetry). There are mainly two classes of power quality problems: one is due to poor quality of current drawn by the load due to the usage of non-linear loads [1] and other is disturbances related to voltage that causes interruption or faults in the power system. These both problems may cause tripping of sensitive electronic equipments like circuit breakers with sensitive relays which causes major consequences in industrial plants where tripping of main equipments can bear the stoppage of the whole production unit with which high costs are associated with it. Electric Power Quality becomes the main concern of the power utilities, end-users, manufacturers and all other customers due to deregulation in the supply. Any change in frequency voltage and current of power system that results in disoperation or failure of system or customer devices is referred as Power Quality (PQ) problem. Main PQ problems are small interruptions, long interruptions, voltage sags[2], voltage spikes, voltage fluctuations, harmonic distortion and voltage swell[2] etc. The main PQ problem is voltage sag which almost shares 70% of all PQ problems. So, we need to avoid PQ problems as much as possible. The PQ has some main parameters:

- Supply voltage without any disturbance.
- Any change in voltage magnitude.
- Voltage Quality.
- Contents of Harmonics in the AC power waveforms.
- Voltages and currents transients.

Voltage dip in supply is defined as the decrease in the normal operating voltage level in between 10 to 90% of the root mean square value of voltage at the power frequencies for duration up to one minute. These are due to faults in transmission and distribution lines, consumer's installation faults, heavy loads and connections of large motors etc. Voltage spikes are the transients of very fast speed and have duration of very short time in PS. These voltage spikes are due to lightning strokes, short-circuits in the line due to breaking of conductors and which causes tripping of circuit breakers etc. Some non-linear loads are Induction motors, variable frequency drives and SMPS etc. are present in the power system. Due to these all there is introduction of third harmonic or fundamental frequency components in the system and it leads to increase in zero sequence currents and also increases the current in the neutral conductor. Also, there is also reduction in the power factor of the system. Voltage fluctuations are the oscillations in the supply voltage. These are due to non-linear nature of the loads like

oscillatory loads, continuously starting and stopping of motors, arc furnaces etc. Very short interruptions are the interruption of electricity supply for some duration of few milliseconds to some 1 or 2 seconds. These are due to opening and closing of circuit breakers or auto-recloses, failure of insulation, flashover of insulator, touching of tree branches with the conductors and lightning etc. Long interruptions are the interruptions of supply voltage for some duration of time i.e. greater than 1 to 2 seconds. These are due to equipment failures in the power system, breaking of lines or poles, human mistakes, storms and failure of protection devices. Voltage swell is the increase in supply voltages for some duration at power frequency for duration of one pulse or more than one pulse up to a time of few seconds. These are due to stopping and starting of heavy loads.

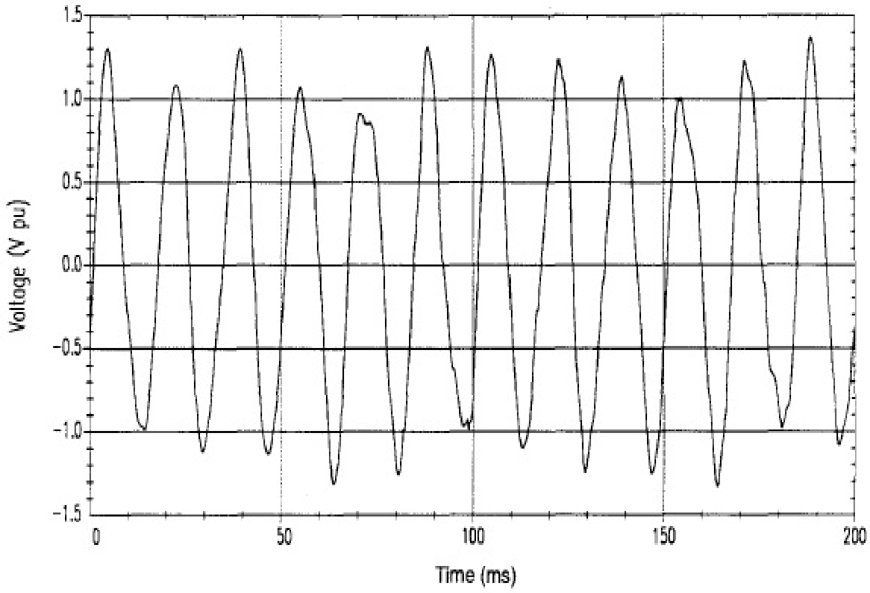

Figure.1: Fluctuations of voltage due to disturbances

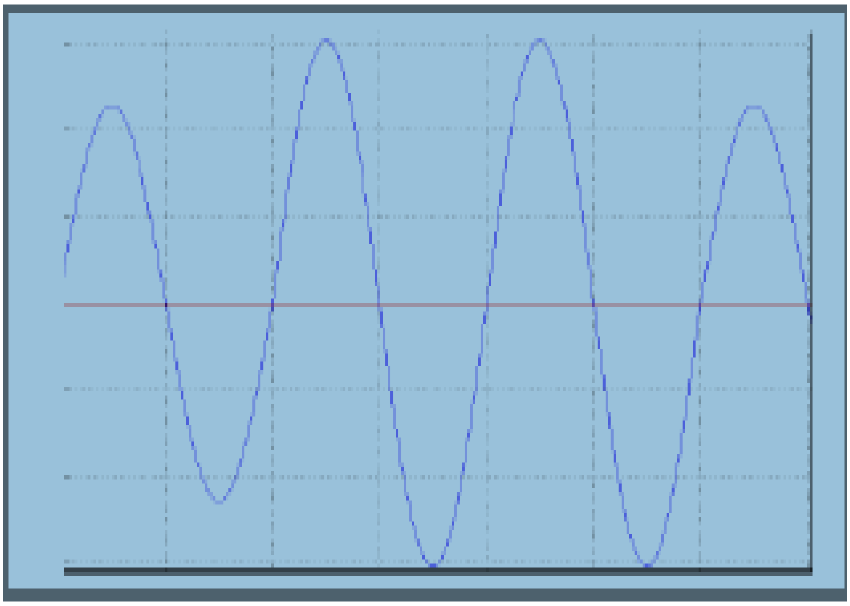

Figure.2: Voltage Swell

2. UPQC CONFIGURATION

In electrical system, many devices are used for compensation like FACTS & other some custom devices to improve the PQ of the system. Some devices are DVR, Active filters, UPQC and DSTATCOM [3, 4] etc. are used for the improvement of PQ related problems of current and voltage. In the last few years, Unified Power Quality Conditioner (UPQC) has become an increased choice of engineers which provides customers a high quality of power. UPQC [5] which is a combination of a shunt Active Power Filter (APF) or DSTATCOM and a series compensator Dynamic Voltage Restorer (DVR) connected together via a common direct dc link [6,7] capacitor. These inject shunt current and series voltage in the system. These devices compensate for disturbances such as voltage sag and swell and current harmonics to protect sensitive loads as well as to improve service stability and reliability. UPQC has three control strategies and these are series control strategy, shunt control strategy and DC link or capacitor control. In Series control strategy the series active filter is provided for the voltage compensation. It generates the voltage that should have to be compensated by the PWM converter and it is put in series with the supply voltage to force the voltage of PCC to become balanced and sinusoidal. In Shunt control strategy the shunt active power filter provides current and the reactive power i.e. if system needs compensation. It means that customers requires a pre-specified quality and reliability of power supply that may include a single or a combination of the specifications like no power interruptions, low THD [8] in load voltage, acceptance of fluctuations, under voltage within specified limits, low phase unbalance.

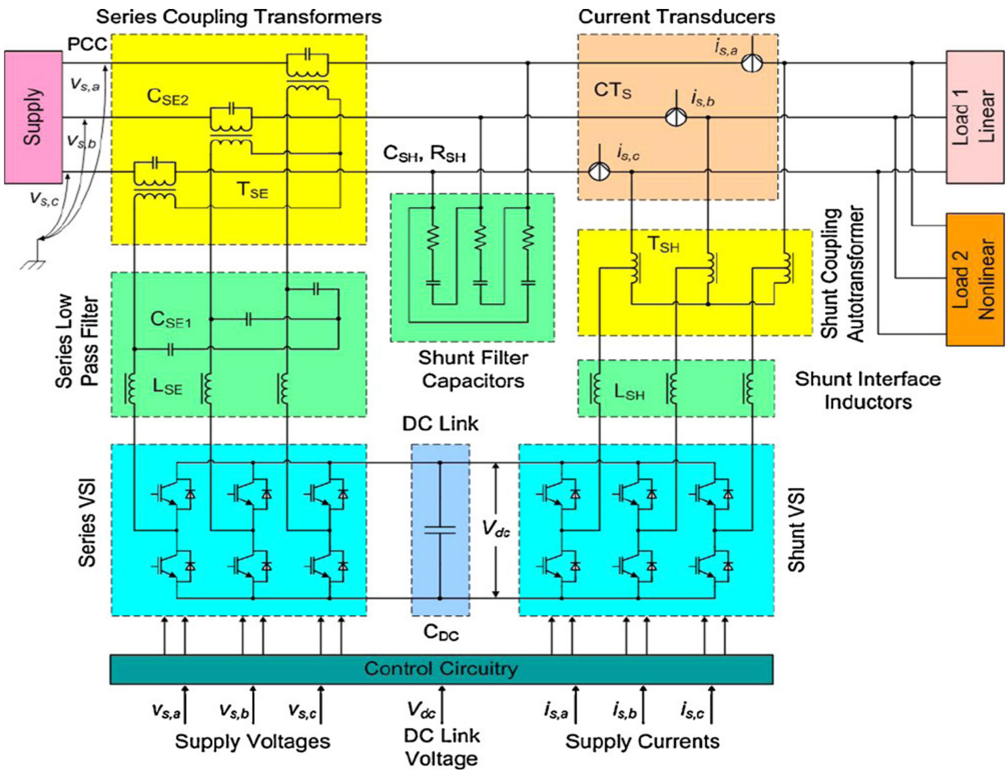

Figure:3 UPQC Model

3. ADAPTIVE NEURO-FUZZY INFERENCE SYSTEM (ANFIS)

In this section, here we have basics of ANFIS [9] network architecture and its hybrid combination learning rule. The idea of basing the fuzzy logic inference procedure on a network structure of feed forward, Jang proposed a fuzzy neural model – the Adaptive Neural Fuzzy Inference System (ANFIS). He said that the architecture of ANFIS [10] is employed to model the non-linear functions, identify all non-linear components online in a control system, and predict unarranged time series. It is basically a hybrid neural-fuzzy technique that brings us the neural networks learning capabilities to fuzzy inference systems. The learning algorithm provides us the membership functions of a Sugeno-type Fuzzy Inference System by using the training input output data. The ANFIS [11] is an implementation of representative fuzzy inference system using a BP neural network-like structure. It has mainly five layers. This concept of neural networks (NN) is started in the late 1800s i.e. an effort is made to describe how the human mind performed in the old days. As year passes by, these networks started playing a very important and big role in the various engineering departments. Neural networks have been applied successfully to image analysis, adaptive control and speech recognition, in order to construct software agents in the control of electrical machines. ANNs are from the family of intelligent algorithms which can be used for control and identification purposes, time series predictions and their classification. NN have the ability to train with various parameters of induction motor. As a non-linear system, they are used for identification of extremely non-linear system parameters with high accuracy. Now a day, the use of NN is to identify and control non-linear dynamic systems has been offered for consideration in various applications because they can provide a wide range of non-linear functions to any desired degree of accuracy. However, their advantage of very good fast parallel computation and fault bear or endure characteristics. Also there have been some proposals into the application of Neural Networks to ac drives, power electronics including speed estimation etc. This technique provides us a fairly good calculation of speed and is very strong to parameter variations. However, the speed estimator of NN is trained sufficiently with various patterns to get good performance of the system. On the other way FL is very successful applications in the control system field which is used for the control of various parameters of the real time systems. This logic combined with NN yields very significant results.

Layer 1: In this layer, input variables i.e. membership functions, input 1 & input 2. Here, triangular or bell shaped membership functions can be used. This layer just supplies the input variables Ix to the next layer, here I = 1 to n.

Layer 2: This layer is membership layer and checks for the weights of each membership functions. It receives the input values Ix from the first layer and act as membership functions to represent the fuzzy sets of the respective input variables. Further, it calculates the membership values which specify the degree to which the input value Ix belongs to the fuzzy set, which acts as the inputs to the next layer.

Layer 3: This layer is called as the rule layer. Each node i.e. each neuron in this layer performs the pre- matching condition of the fuzzy rules i.e. they calculate the activation level of each rule, the number of layers are same as that of the number of fuzzy rules. The node of each layer calculates the weights which are normalized.

Layer 4: This layer is the de-fuzzification layer & it provides the output values Y resulting from the inference of rules. Connections between the layer 3 & layer 4 are

weighted by fuzzy singletons that represent one more set of parameters for the neuro-fuzzy (NF) network.

Layer 5: This layer is the output layer which sums up all the inputs coming from the layer 4 and transforms the fuzzy classification results into a crisp i.e. binary form.

4. SIMULATION MODEL RESULTS USING BASIC MATLAB MODEL W/O ANFIS

In this we have considered a two machine model of the 415 V, 50 Hz line with a source at one end & an RL load at the other end of the system. We have used the distributed parameters of the transmission line. We measure the voltage, current & power at the input side & output side of the transmission line & then compare these values. Now we will connect the UPQC in the middle of the transmission line through circuit breaker.

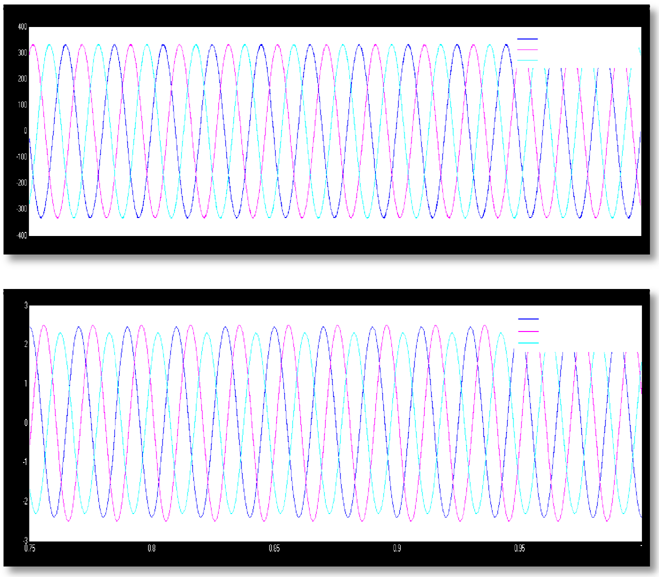

Figure.4: Input Voltage and Input Current

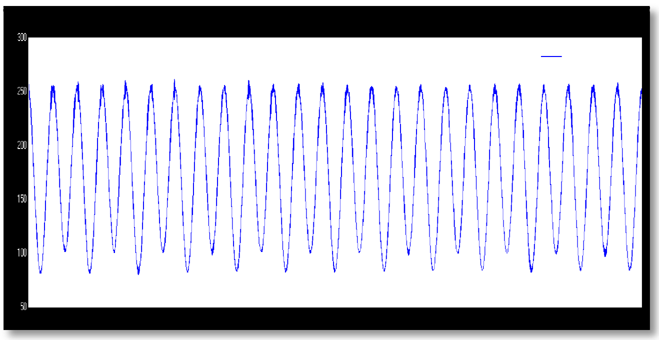

Figure. 5: Input Real Power

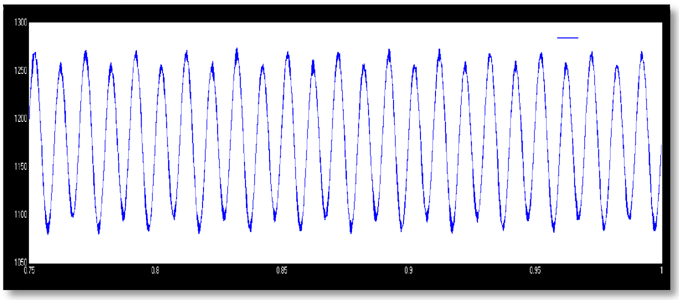

Figure.6: Input Reactive Power

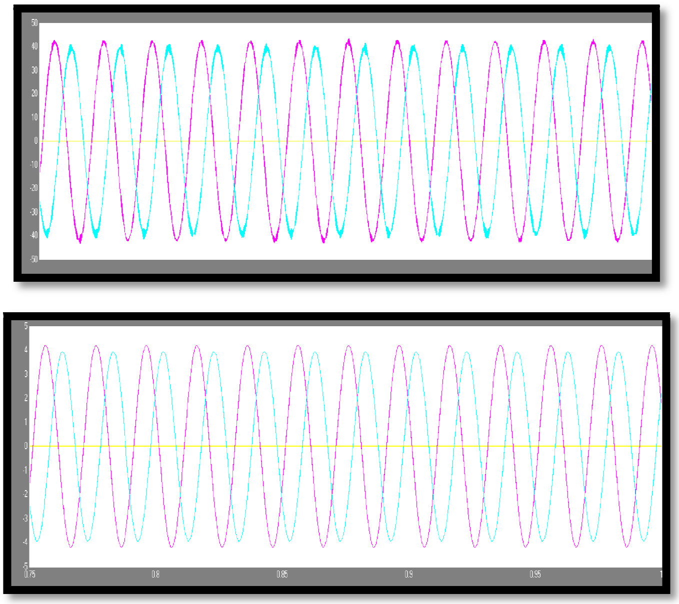

Figure.7: Output Voltage and Current

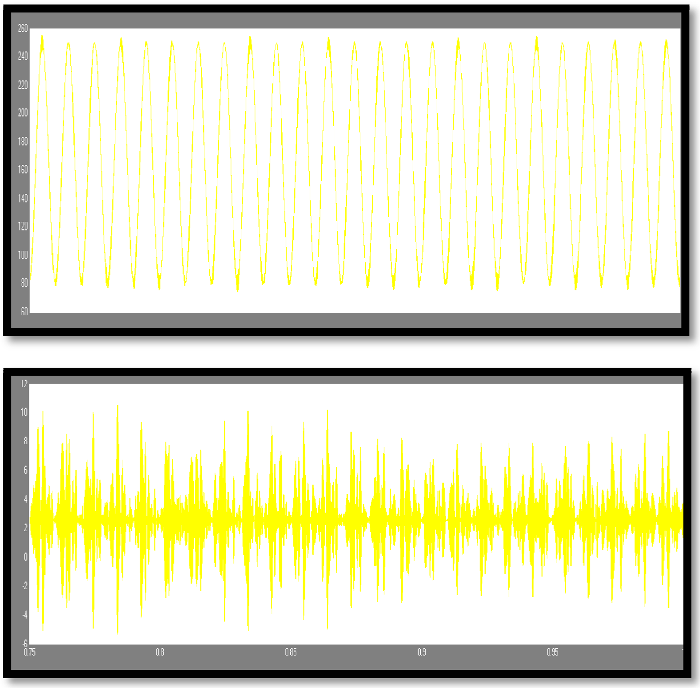

Figure.8: Output Real & Reactive Power

5. SIMULATION MODEL RESULTS USING MATLAB MODEL WITH ANFIS

When we have made a simple two machine model of the system using a source, a 415 V line, an RL load and observe the output waveforms and compare these waveforms with the input waveforms. Now we use UPQC for power quality improvement of the transmission line using advanced controllers which gives instantaneous response for improvement of power quality by minimizing the voltage sag, swell and total harmonic distortion and then results of these all three conventional are compared.

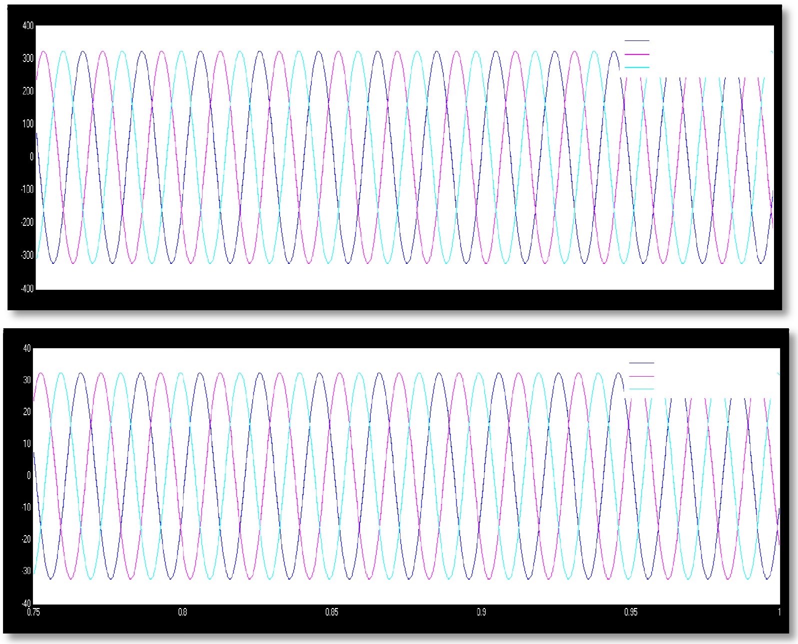

Figure.9: Input Voltage and Current

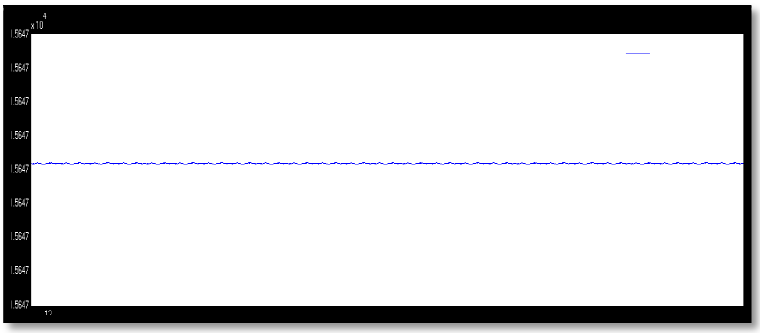

Figure.10: Input Power

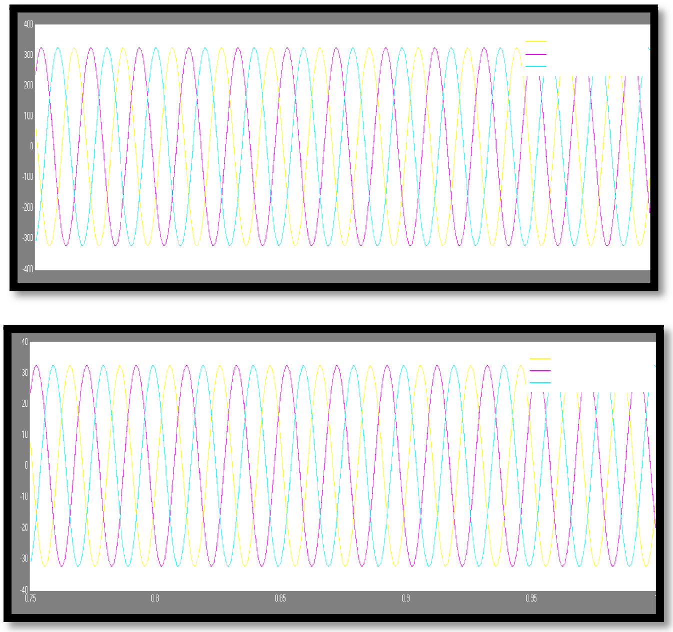

Figure.11: Output Voltage & Current

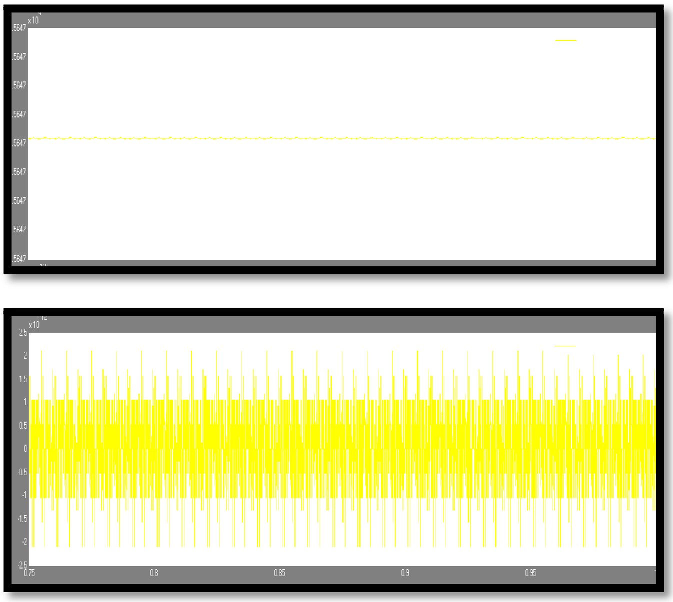

Figure.12: Output Real & Reactive Power

6. CONCLUSION

This paper presents control and performance of UPQC for a distribution line with the help of ANFIS controller. A control system is simulated in switching and in unbalanced conditions. Simulation results show the effectiveness of UPQC in active filtering and controlling real and reactive power through the line. Voltage Regulation and power factor of the distribution line is also improved. This chapter presents an improvement in the real and reactive power flow through the line with UPQC using ANFIS controller when compared to the system without UPQC.

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